

4A22 USER'S MANUAL

VERSION 1.0

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TABLE OF CONTENTS

WARNINGS

WARNINGS	4
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DESCRIPTION

GENERAL	5
---------------	---

HARDWARE CONFIGURATION

I/O ADDRESS	7
INPUT CONNECTOR	7

A-D OPERATION

GENERAL	8
CONVERSION RATE	8
CALIBRATION.....	9
ACCURACY.....	9

4A22 SOFTWARE

GENERAL	10
4A22DRVR	10
4A22DRVR RECORD STRUCTURE	11
4A22DRVR FUNCTIONS.....	11
4A22DRVR RETURN CODES	13
4A22DCFG.....	14
SEQUENCE FILE FORMAT	15
DATA AVERAGING	17
4A22DRDM.....	19

REFERENCE INFORMATION

SPECIFICATIONS	21
WARRANTY	23
SCHEMATICS.....	25

WARNINGS

HIGH VOLTAGES

The 4A22 analog ground is isolated from system ground and can be at dangerous potentials during normal operation. DO NOT touch the 4A22 card or the input section shield when operating.

STATIC ELECTRICITY

CMOS integrated circuits on the 4A22 can be damaged by exposure to electrostatic discharges. The following precautions should be taken when handling the 4A22 to prevent possible damage.

- A. Leave the 4A22 in its antistatic bag until needed.
- B. All work should be performed at an antistatic workstation.
- C. Ground equipment into which 4A22 will be installed.
- D. Ground handling personnel with conductive bracelet through 1 megohm resistor to ground.
- E. Avoid wearing synthetic fabrics, particularly Nylon.

DESCRIPTION

GENERAL

The 4A22 is low power integrating 18 bit data acquisition system for the PC/104 bus. The 4A22 has 14 input channels with 500V isolation from system ground. The analog inputs have software selectable 0.5V or 5V full scale ranges. The galvanic isolation of input signals from the computer system ground eliminates ground loop problems common with high resolution A-D converters and allows floating measurements to be made.

The 4A22 requires on +5V power. Total power supply current is less than 50 mA. A small amount (+6V and -6V, 2.5 mA max.) of isolated power is available at the analog input connector for powering isolated signal conditioning circuits .

There are different 4A22 models for optimum 50 and 60 Hz power line rejection. The conversion rate of the 4A22 is 16 conversions per second (60 Hz model) and 13.33 conversions per second (50 Hz. model).

The 4A22 can be programmed to generate an interrupt when it has completed a conversion, allowing background data acquisition. The 4A22 can use any of the AT bus interrupts. The IRQ line selection is software programmable (no interrupt jumpers).

4A22 calibration data is stored in an on card EEPROM, so no zero or full scale adjustment potentiometers are needed. In fact, calibration requires no access to the 4A22 card itself. An on card temperature readout channel allows the driver software to compensate for the 4A22's temperature coefficients.

Driver software for background data collection is supplied with the 4A22. This driver acquires data in the background on an interrupt driven basis, scales and auto zeros the data, and stores the processed data in an application program readable FIFO.

The channel and range sequence that the background task acquires is programmable via a simple ASCII file. Source code for the driver program and example interfacing programs is supplied with the 4A22.

HARDWARE CONFIGURATION

I/O ADDRESS

The only user settable hardware option on the 4A22 card is the base I/O location. The 4A22 card uses 8 contiguous addresses in I/O space. The 4A22 base address has seven optional locations. These are set with jumpers W1, W2, and W3. Jumper blocks W1, W2, and W3 are three pin headers with two valid jumper positions, up and down. Up means away from the J1 and J2 bus connectors.

The following table shows the 4A22 base addresses for different jumper settings:

BASE ADDRESS	W1	W2	W3
0200H	down	down	down
0208H	down	down	up
0210H	down	up	down
0218H	down	up	up
0220H	up	down	down
0228H	up	down	up
0238H	up	up	down
(DISABLED)	up	up	up

The all up position completely disables the 4A22 card and can be used when checking for I/O conflicts.

This set of base addresses is determined by PAL U17, and can be changed if necessary. Contact MESA if you require a different set of I/O base addresses.

HARDWARE CONFIGURATION

I/O CONNECTOR

The 4A22 uses a 34 pin, right angle male header for its analog input connector. The suggested mating connector is AMP PN 746194-9. This is an IDC (flat cable) type connector.

The analog input connector pinout is as follows:

PIN	FUNCTION	PIN	FUNCTION
1	Input shield	2	Input shield
3	Input 0	4	Input 1
5	Input 2	6	Input 3
7	Input 4	8	Input 5
9	Input 6	10	Input 7
11	Input shield	12	Input shield
13	Input 8	14	Input 9
15	Input 10	16	Input 11
17	Input 12	18	Input 13
19	NC	20	NC
21	Input shield	22	Input shield
23	Input common	24	Input common
25	+ 2.5V reference	26	+ 2.5V reference
27	Input common	28	Input common
29	Input shield	30	Input shield
31	NC	32	Unreg -6 power
33	Input shield	34	Unreg +6 power

Note that all analog inputs use Input common as their ground reference, not Input shield. The input shield connection is intended for use as an input guard only and may be several millivolts away from true input ground.

A-D OPERATION

GENERAL

The 4A22 uses a Maxim MAX132 18 bit integrating A-D converter. This converter has low power requirements and a serial interface that make it suitable for the 4A22's isolated input design.

Since the maximum conversion rate of the 4A22 is 16 conversions per second, and at that conversion rate the overhead of a software calibration routine is minimal, a software calibration scheme was chosen to eliminate the need for gain and zero potentiometers.

Each 4A22 card has a 1K bit serial EEPROM on card that contains calibration constants for that specific card. The EEPROM is loaded with these constants during the factory calibration routine. These constants are used by the supplied driver software to correct the raw A-D output data. Zero offset is corrected by sampling a grounded input channel. The zero offset is different on the high and low ranges, so zero readings must be taken with both range settings. The data from the zero channel is then subtracted from the raw A-D data from the other channels. The 4A22 has a temperature readout channel that is used to compensate for the various temperature drifts in the 4A22 circuitry.

The 4A22 has two input voltage ranges, a high range of -5V to +5V and a low range of -0.5V to +0.5V. These ranges are software selectable.

14 input channels are available for user inputs. These are channels 0 through 13. Channel 14 is a temperature readout channel used by the calibration software, and channel 15 is the zero reference channel.

Because of the complexity of the serial interface and software calibration scheme, it is suggested that the driver always be used to access the 4A22. If you wish to write your own code to access the 4A22, it is suggested that you examine the various 4A22 source files for information on how to access the calibration record, etc. When the driver software is used, calibrated data is presented as a 32 bit integer that represents the input voltage in microvolts.

CONVERSION RATE

The basic conversion rate of the 4A22 is 16 conversions per second. This rate is determined by a quartz crystal and is accurate to +/- 200 PPM (about 20 seconds a day).

Because auto zero and temperature readings must be performed in the input scanning loop, the throughput of user data is somewhat less. For example, an input scanning loop might read the 13 user inputs, do a high range auto zero operation, a low range auto zero operation, a temperature reading and then repeat. This loop would take one second, and read 13 user channels. It is possible to improve the throughput by interleaving the housekeeping chores. See the 4A22 SOFTWARE section for an example of interleaving the housekeeping.

A-D OPERATION

CALIBRATION

The 4A22 is calibrated at MESA but can be re-calibrated if necessary. To do a voltage only calibration requires that reference voltages of 4V and .4V are available. The reference voltage source should be accurate to 50 PPM or better.

A complete calibration requires a temperature controlled oven in order measure the gain temperature coefficients and calibrate the temperature channel. It is suggested the original temperature coefficient data be used unless there is a compelling reason to change it.

Calibration is performed via the program 4A22CAL.EXE. 4A22CAL is invoked with the hexadecimal port address of the 4A22 plus the optional T parameter if a temperature calibration is to be performed:

```
4A22CAL 200 [T]
```

4A22CAL prompts you to connect different voltages to the input channel. When 4A22CAL is done, it will write the new calibration data into the 4A22's EEPROM. If the T option is specified, 4A22CAL will do a temperature only calibration.

We do supply 4A22CAL to the user but strongly suggest that 4A22 card calibration be done at MESA.

ACCURACY

The 4A22 has a basic accuracy limit of $\pm 0.05\%$. This applies over the full operating temperature range of the card. This accuracy assumes that the supplied 4A22 driver software is used to calibrate the raw data from the 4A22's A-D chip. The main source of inaccuracy is due to mechanical stress on the surface mount reference divider and 10 : 1 input divider resistors. We are changing the 4A22 artwork to use through-hole components for these dividers in the next card revision. This should improve the basic accuracy to about $\pm 0.02\%$.

In order to minimize calibration shifts do to mechanical stress, handle the 4A22 gently, and try not to twist or flex the card. When the 4A22 card is installed in the PC/104 stack, press the connectors together by pushing on the female connector, not the PC card.

The 0.5V range is inherently more accurate than the 5V range since the input signal goes directly to the A-D converter in this case.

The temperature channel is mainly for internal use and calibration is only guaranteed to be accurate to $\pm 5^{\circ}\text{C}$.

4A22 SOFTWARE

GENERAL

The 4A22 uses a TSR driver program to access the 4A22 hardware. This driver hides many of the details of accessing the 4A22, making the data acquisition application programs task easier. The driver uses the EEPROM calibration data to calibrate the A-D data, does auto zero cycles for both the high and low ranges, and compensates for the total A-D gain temperature coefficient.

The driver allows data acquisition to be done as a background (interrupt driven) task, with the acquired data saved in a driver maintained FIFO. The standard FIFO size is 64 entries deep, allowing 4 seconds of samples to be acquired without processor intervention (other than servicing the interrupt). This means that the foreground task can easily poll keyboards, do disk I/O or other tasks without interfering with the data acquisition sample rate;

4A22DRVR

The TSR driver is called 4A22DRVR.EXE. 4A22DRVR is launched with three command line parameters. These parameters are the 4A22 base address, the hardware interrupt number that the 4A22 will use, and the software interrupt number used for communication with the driver. For example:

```
4A22DRVR 200 5 60
```

Would launch the driver with a 4A22 base address of 200H, a hardware interrupt number of 5, and a software interrupt number of 60H. Note that the base address and software interrupt are specified in hex, but the hardware interrupt is specified in decimal as is standard practice with hardware interrupts.

The base address must match the base address setting of the 4A22 in the system. This is the address selected via jumpers W1, W2, and W3. The hardware interrupt must not be used by any other peripheral in the system. IRQ 2 and 5 are frequently available in XT PC/104 systems, while at least one of IRQ 5, 9, 10, 11, 12, and 15 are available in AT PC/104 systems. The software interrupt uses one of the so-called user interrupt vectors from 60H to 6FH. The driver attempts to check if the software interrupt is used before installing itself, but you should make sure that no other installed software uses the same interrupt vector.

Once installed, all communication to the driver is done via the software interrupt. The same calling convention and data record structure is used for all driver functions. The driver is accessed by calling its software interrupt with the register pair CX:BX (CX=segment, BX=offset) pointing to the data record.

4A22 SOFTWARE

4A22DRVR RECORD STRUCTURE

To avoid a multiplicity of record structures for 4A22DRVR communication, a single record is used. It is the responsibility of the calling program to allocate the record structure and provide 4A22DRVR with a pointer to it. The calling program must set CX:BX to point to the record on entry. The record size is 13 bytes total.

A range value of 0 specifies the low (0 to +- 0.5V) range and a 1 specifies the high range (0 to +- 5V). When status is returned, true status is represented by an 0FFH byte in the status field and false status by a 00 in the Status field. When raw A-D data is returned, the data is just as read from the converter except that it is sign extended to 32 bits. When calibrated data is returned from the A-D, it returns as a signed (twos complement) 32 bit integer expressed as microvolts.

The record structure is as follows:

DATA	DATA SIZE	BYTE OFFSET
Function number	byte	0
Return code	byte	1
Status	byte	2
Pointer offset	word (16 bits)	3
Pointer segment	word (16 bits)	5
Data	longint (32 bits)	7
Channel	byte	11
Range	byte	12

4A22DRVR FUNCTIONS

These are determined by the function number in the Function number field of the data record.

The following is a list and brief description of the driver functions. For more information on the 4A22DRVR functions, you should refer to the 4A22DRVR source code in the SOURCE directory of the 4A22 distribution floppy. Applicable files are 4A22DRVR.PAS, 4A22LOW.PAS and 4A22DFUN.PAS.

4A22 SOFTWARE

4A22DRVR FUNCTIONS

FUNCTION	NUMBER
DrFuncGetVersion Returns Version # in Data field	0
DrFuncGetConvStatus Returns converter running status is Status field: running = true, stopped = false.	1
DrFuncGetDriverStatus Return configuration status of driver is Status field: true = configured, false = not configured.	2
DrFuncGetFIFODataStatus Return FIFO data available status in Status field: true = data available, false = FIFO empty	3
DrFuncGetFIFOvflStatus Return FIFO overflow status in Status field: true = FIFO has overflowed, false = no overflow. Overflow status can be cleared by stopping the conversions and then restarting them.	4
DrFuncStartConversions Start background data conversions.	5
DrFuncStopConversions Stop background data conversions. Also clears FIFO, FIFO overflow status and scan count.	6

4A22 SOFTWARE

4A22DRVR FUNCTIONS

FUNCTION	NUMBER	
DrFuncGetCalData	7	Returns calibrated data in Data field, enter with channel number in Channel field and range in Range field.
DrFuncGetRawData	8	Returns low range raw data in Data field, enter with channel number in Channel field and range in Range field;
DrFuncGetTemperature	9	Returns low range zero reading in Data field
DrFuncGetZero	10	Returns zero reading in Data field, enter with range in Range field
DrFuncGetFIFOData	11	Returns FIFO data, FIFO channel and FIFO range in Data, Channel, and Range fields
DrFuncGetScanCount	12	Returns the current scan count (number of times around the data aquisition loop) in the Data field
DrFuncGetAtoDRecPtr	13	Return pointer to AtoD Record in Pointer segment and Pointer offset fields
DrFuncGetCalibRecPtr	14	Return pointer to Calibrate Record Pointer segment and Pointer offset fields

4A22 SOFTWARE

4A22DRVR RETURN CODES

The return code field of the Interrupt record indicates whether or not the function was successful, or if the function failed, why. Return codes are as follows:

RETURN CODE	MEANING
00	Successful completion
01	Failed
02	Bad parameter

Failed usually means an unimplemented function. Bad parameter means that the channel or range number is not valid.

4A22DCFG

After 4A22DRVR is installed, it need to be configured in order to set up its operating parameters and background data aquisition loop. This is done with the program 4A22DCFG. 4A22DCFG loads various user specified parameters and a sequence table into the driver. The user parameters and sequence table are in an ASCII text file. This file is referered to as a sequence file. 4A22DCFG is invoked with the sequence file filename and the 4A22DRVR software interrupt number on the command line:

```
4A22DCFG SEQFILE 60
```

Would configure the driver using software interrupt 60H with the sequence file SEQFILE.

SEQUENCE FILE FORMAT

The sequence file specified on the 4A22DCFG command line is an ASCII text file consisting of lines terminated with a CR LF. Each line starts with a token (an ascii name) and zero, one or two parameters. A combination of a token followed by its parameters is called a statement. Lines that start with a ; (semicolon) are ignored, and can be used for comments. The tokens are not case sensitive, but are printed here in upper case for emphasis.

There is an example sequence file (SEQFILE) in the DRIVER directory of the 4A22 distribution floppy. The sequence file has three sections, a parameter specification section, a A-D startup section , and a data aquisition loop section. The maximum length of the combined A-D startup and aquisition loop sections is 128 statements.

4A22 SOFTWARE

SEQUENCE FILE FORMAT

The parameter specification section has the four statements:

```
DAVETIMES XX
ZAVETIMES XX
ZRESETSTEP XX
DRESETSTEP XX
```

These tokens are followed by a single parameter (XX). The valid parameter range is 1 to 255. These parameters determine how the 4A22 driver averages its input and zero reference inputs. The ZRESETSTEP and ZAVETIMES should not be changed from the values in the example file, as these have been found to be optimum. The DAVETIMES and DRESETSTEP parameters determine the data averaging operation. See the DATA AVERAGING section for more information.

The next section is the A-D startup section. This section is used to get initial values of temperature, and zero values for auto zero operation. These operations will take place only one time when the StartConversions command is given. This is so that the first data acquired in the data acquisition loop will be valid. Any valid statement can be put in the A-D startup section but usually all that is required are the housekeeping statements. These are :

```
ZEROH
ZEROL
TEMP
```

These statements need no parameters. A ZEROH statement causes the driver to make a zero reading at the high range setting. A ZEROL statement causes the driver to make a reading at the low range setting. A TEMP statement causes the driver to make a temperature reading. The ZEROL and TEMP operations must be done before the 4A22 will return valid data, as these values are used in calibration. The ZEROH operation is only necessary if high range readings need to be made.

The last section of the sequence file is the acquisition loop section. This section has the list of A-D read operations that the driver will do. This list of operations will be sequentially executed, and repeated indefinitely. The acquisition loop section must start with the LOOPSTART statement. All statements in the acquisition loop section cause a A-D read operation to take place. This means that the total acquisition loop time is 1/16 second times the number of operations in the acquisition loop. This fact can be used to assign a time reference to the A-D samples.

4A22 SOFTWARE

SEQUENCE FILE FORMAT

The following statements can be used in the acquisition loop:

```
READ CC RR
READAVE CC RR
READRAVE CC RR
PUSH CC RR
PUSHAVE CC RR
PUSHRAVE CC RR
TOSS CC RR
ZEROH
ZEROL
TEMP
```

CC is a channel number and can have range from 0 to 15. RR is a range specifier, and can be either "HI" or "LO".

READ statements cause the data read from the A-D to be stored in a table for later access. This access can be asynchronous to the data acquisition loops operation. This means that for channels and ranges specified in READ statements, the driver can be asked for the data at any time and will return the latest available data for that channel and range. READAVE and READRAVE statements have a similar operation, but perform data averaging on the acquired data. It is the responsibility of the user program that accesses the driver to only ask for data that has been stored by the acquisition loop. All other data is undefined.

PUSH statements cause A-D data, channel number, and range to be "PUSHED" onto the data FIFO. The data FIFO is a first in first out buffer with each entry consisting of A-D data, the channel the data came from, and the range setting. The FIFO size is normally 64 entries deep. The advantage of this FIFO structure is that the time sequence of the A-D data is not lost as long as the user program does not let the FIFO overflow. Since the maximum A-D conversion rate is 16 Hz, and the FIFO depth is 64, the user program must only attend to the FIFO about every 4 seconds. The PUSHAVE and PUSHRAVE statements are similar to the PUSH statement except that they push averaged data onto the FIFO.

TOSS statements read the A-D and simply discard the data. The main use of TOSS statements is to pad the data acquisition loop so that the total time comes out to some desired amount. For example a data acquisition loop consisting of one PUSH statement, a ZEROL statement, a TEMP statement, and 13 TOSS statements would have a total length of 16, and therefore a repeat rate of 1 second. This means that data would only accumulate in the FIFO at a rate of 1 reading per second

4A22 SOFTWARE

SEQUENCE FILE FORMAT

If the acquisition loop is to run continuously, you should include a ZEROL and TEMP token in the loop. You should also include a ZEROH token if you use the high range. The time spent on these housekeeping chores can be minimized by interleaving them with the normal data acquisition steps. For example: if your acquisition loop needs to PUSH 4 channels of data, the acquisition loop section could contain the following sequence:

```
PUSH 1 HI
PUSH 4 LO
PUSH 8 LO
PUSH 7 HI
TEMP
PUSH 1 HI
PUSH 4 LO
PUSH 8 LO
PUSH 7 HI
ZEROL
PUSH 1 HI
PUSH 4 LO
PUSH 8 LO
PUSH 7 HI
ZEROH
```

This would keep the overhead of the housekeeping chores to 1/5 of the readings. This technique can also be used to mix frequently read channels with channels that are only read occasionally. The only limitation is that the total sequence length must be 128 statements or less. This includes any A-D startup statements.

DATA AVERAGING

Data read from the 4A22 A-D can optionally be averaged by the 4A22DRVR software. Averaging can be used for noise filtering or where it is desired to low pass filter the input signal. Two types of averaging are available: running average, and resettable running average. The running average is useful for low pass filtering of the input signal. Its operation is determined by the input signal sampling rate as determined by the acquisition loop, and the DAVETIMES parameter.

4A22 SOFTWARE

DATA AVERAGING

The running averager works as follows: Every time an averaged channel is read or pushed, the A-D data is summed to an accumulator. This accumulator is DAVETIMES's larger than the (averaged) data. The accumulator is then scaled by multiplying it by $DAVETIMES/(DAVETIMES+1)$. The averaged data is then obtained by dividing the accumulator by DAVTIMES. The larger the DAVETIMES parameter, the smaller the effect new data has on the average. The accumulator contents are saved on a per channel basis. The total effect of the running average is that of a linear low pass filter. The running average is selected by using the PUSHAVE or READAVE statements in the sequence file.

One disadvantage of the running average is that it may take a very long time to settle after a step change in the input. This may be desired if extremely slow time constant filtering is desired but is undesirable for simple noise filtering.

The resettable averager solves this problem by nonlinear behavior for large input steps. The resettable averager operation is basically the same as the running average except that new input data that differs from the average by more than DRESETSTEP counts causes the averager to be reset to the new value. New data that is less than DRESETSTEPS different from the current average will simply be averaged in the normal way. DRESETSTEP is specified in A-D converter counts. For A-D converter noise filtering a DRESETSTEP of 8 is appropriate. The resettable running average is selected by using the PUSHRAVE or READRAVE statements in the sequence file.

Another use of the resettable average is to establish initial conditions for the running averager. Both averagers share the same data accumulators, so by using the resettable average in the A-D startup section of the sequence file, the averager will be preset to the first reading from the A-D.

4A22 SOFTWARE

4A22DRDM

4A22DRDM is a simple demonstration program of the 4A22 card & 4A22DRVR combination. 4A22DRDM reads data from the drivers FIFO and displays it on the screen. 4A22DRDM determines where to display the data by its channel number read from the FIFO. 4A22DRDM is launched with the software interrupt number of the driver on the command line:

```
4A22DRDM 60
```

Would launch the demo program, and have the program use software interrupt 60H to communicate with the 4A22DRVR program.

Assuming that 4A22DRVR is not already loaded, the full sequence of commands needed to run 4A22DRDM would be as follows:

```
4A22DRVR 200 5 60
4A22DCFG SEQFILE 60
4A22DRDM 60
```

The assumptions here being that the 4A22 is located at the default 200H base I/O location, that IRQ 5 is free and unencumbered, and that software interrupt 60H is free.

The sequence file SEQFILE would of course have to contain some PUSH, PUSHAVE or PUSHRSAVE statements in its aquisition loop section for 4A22DRDM to display anything.

REFERENCE INFORMATION

SPECIFICATIONS

	MIN	MAX	UNIT	NOTES
POWER SUPPLY				
Voltage	4.5	5.5	V	
Supply current (no external load)	---	75	mA	
ISOLATED POWER				
Voltage	5.5	7.25	V	
Load current	---	2.5	mA	+ - Loaded
INPUT CHARACTERISTICS				
Input current	-1	+1	nA	at 25°C
Capacitance to system ground	---	50	pF	
Isolation voltage	---	500	VDC	
Common mode dV/dT	---	20	V/uSec	
Maximum input voltage	-6	+6	V	
ACCURACY				
Resolution	---	18	bits	
Calibrated accuracy 0.5V range	-.05	+.05	% FSR	
Calibrated accuracy 5V range	-.05	+.05	% FSR	
Uncalibrated accuracy 0.5V range	-1	+1	% FSR	
Uncalibrated accuracy 5V range	-2	+2	% FSR	
Auto-zeroed 0.5V range offset	-20	+20	uV	
Auto-zeroed 5V range offset	-100	+100	uV	
Calibrated gain TempCo	-5	+5	PPM/°C	
Uncalibrated gain TempCo	100	+100	PPM/°	

REFERENCE INFORMATION

BUS LOADING:

Input capacitance	---	15	pF
Input leakage current	---	5	uA
Output drive capability	150	---	pF
Output sink current	8	---	mA

ENVIRONMENTAL:

Operating temperature range			
-I version	-40	+85	°C
-C version	0	+70	°C
Relative humidity	0	90	Percent
			Non-condensing

REFERENCE INFORMATION

WARRANTY

Mesa Electronics warrants the products it manufactures to be free effects in material and workmanship under normal use and service for the period of 2 years from date of purchase. This warranty shall not apply to products which have been subject to misuse, neglect, accident, or abnormal conditions of operation.

In the event of failure of a product covered by this warranty, Mesa Electronics, will repair any product returned to Mesa Electronics within 2 years of original purchase, provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may at its option, replace the product in lieu of repair.

With regard to any product returned within 2 years of purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operation, repairs will be billed at a nominal cost.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. MESA ELECTRONICS SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify Mesa Electronics, giving full details of the difficulty. On receipt of this information, service data, or shipping instructions will be forwarded to you.
2. On receipt of the shipping instructions, forward the product, in its original protective packaging, transportation prepaid to Mesa Electronics. Repairs will be made at Mesa Electronics and the product returned transportation prepaid.

REFERENCE INFORMATION

REFERENCE INFORMATION

SCHEMATIC DIAGRAMS